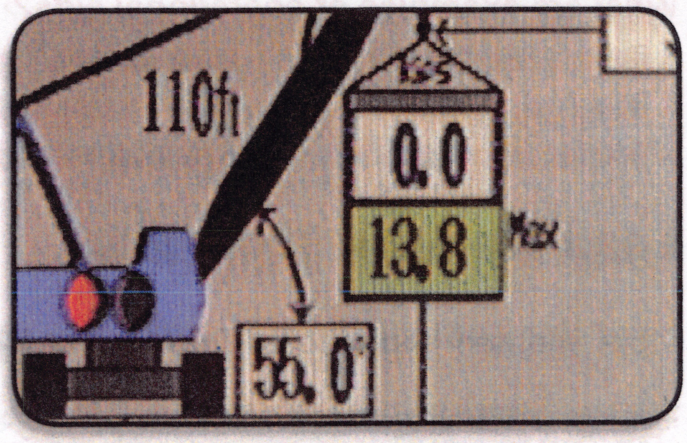
Module 25
Operational Aids and Safety Devices



Learning Objectives

By the end of this section, you will:

1. Know the importance of load moment indicators.
2. Understand why a crane should be equipped with an anti two-blocking device.
3. Be aware of outrigger position indicators.
4. Be aware of load indicating devices.
5. Be aware of boom angle, boom length and drum rotation indicators.

"Safety devices and operational aids must not be used as a substitute for the exercise of professional judgment by the operator." 1926.1417(k)

Operational Aids

According to OSHA, the devices listed in the subpart 1926.1416, are required on all equipment covered under this subpart, unless otherwise specified.

Operational aids must not be used as a substitute for the exercise of professional judgment by the operator

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What are operational aids?

OSHA states they are "Devices that assist in the safe operation of the crane by providing information or automatically taking control of a crane function."

ASME/ ANSI Standard B30.5 provides a similar definition - "Operational Aid - An accessory that provides information to facilitate operation of the crane or that takes control of particular crane functions without an action of the operator when a limiting condition is sensed."

ASME SETTING THE STANDARD B30.5

What are examples of operational aids?

- » Boom angle indicator.
- » Boom hoist limiter.
- » Anti-two block system.
- » Load weighing device.
- » Capacity indicator (load moment indicator).
- » Rated capacity limiter.

Load Moment Indicators

Load Moment Indicators, or LMI's, are common operator aids.

Safe load indicating systems for mobile cranes have been in existence for over 50 years. Over the past 20 years, devices capable of measuring load moment have become standard on most every type of crane used worldwide. All cranes with a maximum rated capacity of 3 tons or more shall have a load indicator, rated capacity indicator, or rated capacity load limiter.

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1926.1416(e)(4)(i)

Load moment indicators signal the operator when the lift being attempted is approaching or has gone beyond the crane's capacity.

Audible and visual signals warn the operator when the crane reaches a dangerous overload situation and may tip. In most cases, these devices can also lock out the hoist control when an overload condition exists. It is important that the operator be aware of not only the load on the hook but also the true load radius, dynamically as the load increases on the boom.

Load moment systems measure and account for these dynamics:

- Forces in the boom hoist structure
- Load on hook
- Boom weight
- Dynamic forces on the boom

It is imperative that the operator be aware of not only the load on the hook but also of the true load radius, dynamically, as the operator increases the load on the boom. This is the big advantage of a load moment system. A load moment system, by monitoring load moment and by compensating for the true deflection under load, can give an operator an indication of exactly where the operator is on the load chart for that machine. If only the hook block load is monitored, the true load on the boom and its effects on radius are not considered.

Cranes today have lighter booms with more elastic steels which results in dramatically greater boom deflection. This is very important because as the boom deflects under an actual load it increases the load radius. This increases the load moment proportionately. An increase in radius of 15% increases the load on the crane by 15%. It is extremely important that the operator be aware of these dynamic changes affecting the crane.

Conventional lattice boom cranes work under a different principle which reduces the impact of deflection. The pendant ropes supporting the boom tip create an offsetting force. Generally, total deflection has much less impact upon radius than it does with telescopic cranes. There are still however, great advantages to a load moment system on a conventional crane.

Case Study

LMIs only work if correct information is entered.

December 1, 2012 on a major project in London, a 130-ton Tadano Faun ATF110G-5 mobile crane up-ended and came to rest on two steel columns. Fortunately, nobody was injured and no major damage was sustained. Early indications revealed that human error was a major contributory factor. If the wrong counterweight detail is entered into the LMI and exceeds that which has been actually installed, the audible and visual warning devices will not activate. That appears to be the case here. Generally speaking mobile cranes are not fitted with counterweight detectors linked into the load moment indicator, although an increasing number are becoming available with outrigger position sensors, which will eventually become standard equipment. Unfortunately, when a little extra capacity is required, an operator can be pressured to cheat the system by programming in a larger counterweight than what is really installed. This is an unacceptable practice that can result in loss of life and equipment.

Compliance with rated capacity:

1. The equipment must not be operated in excess of its rated capacity.
2. The operator must not be required to operate in excess of its rated capacity.

What is the difference between an indicator and a limiter?

» An indicator is a passive device that monitors and warns the operator about an overload or unsafe condition. A limiter is a device that also monitors the movements, will warn the operator about an approaching unsafe condition, but will also prevent the crane from any movement that will overload it. Such devices will automatically warn the operator, stop or restrict crane motion or function when the safe working load is approached or has been exceeded.

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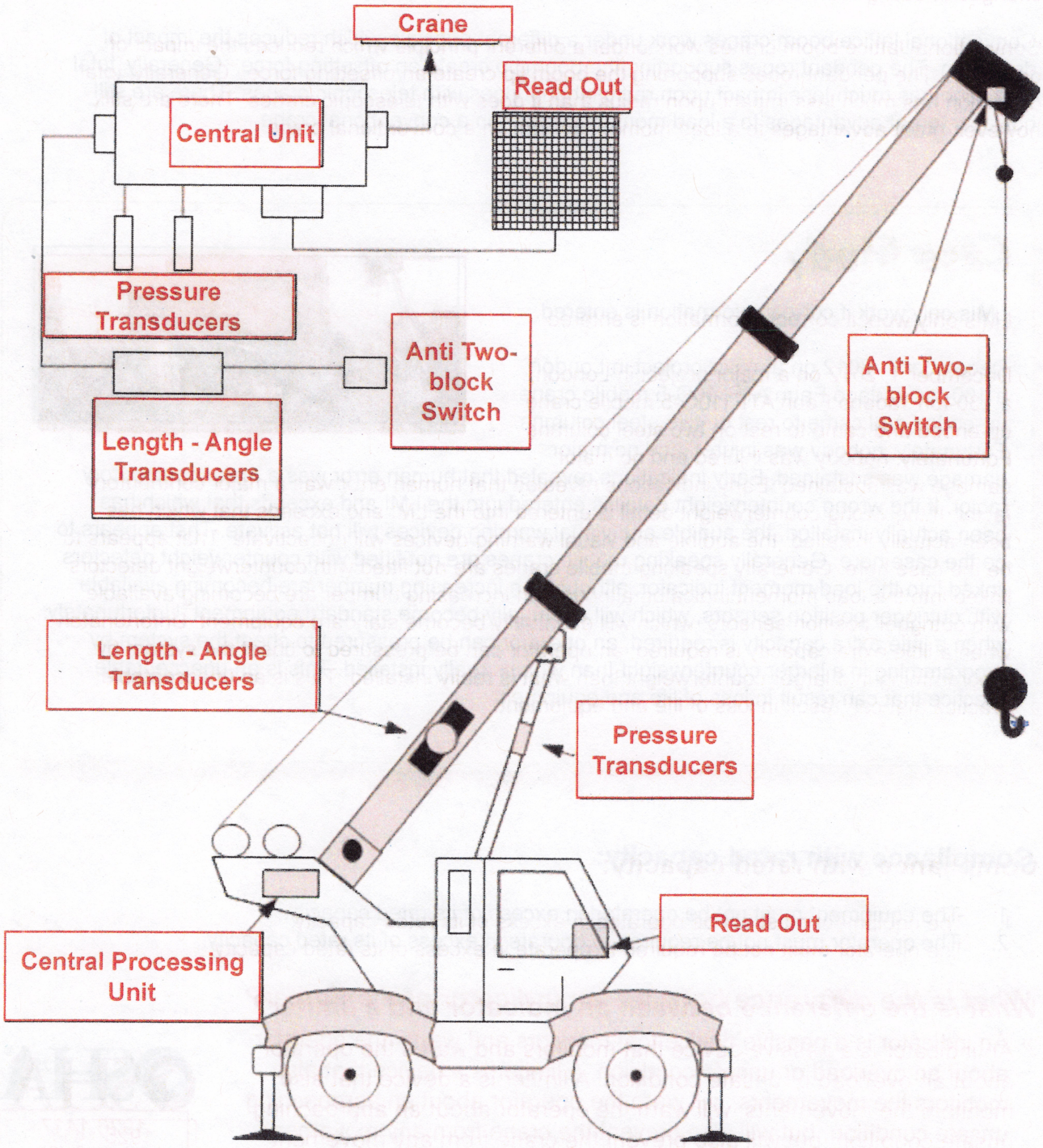
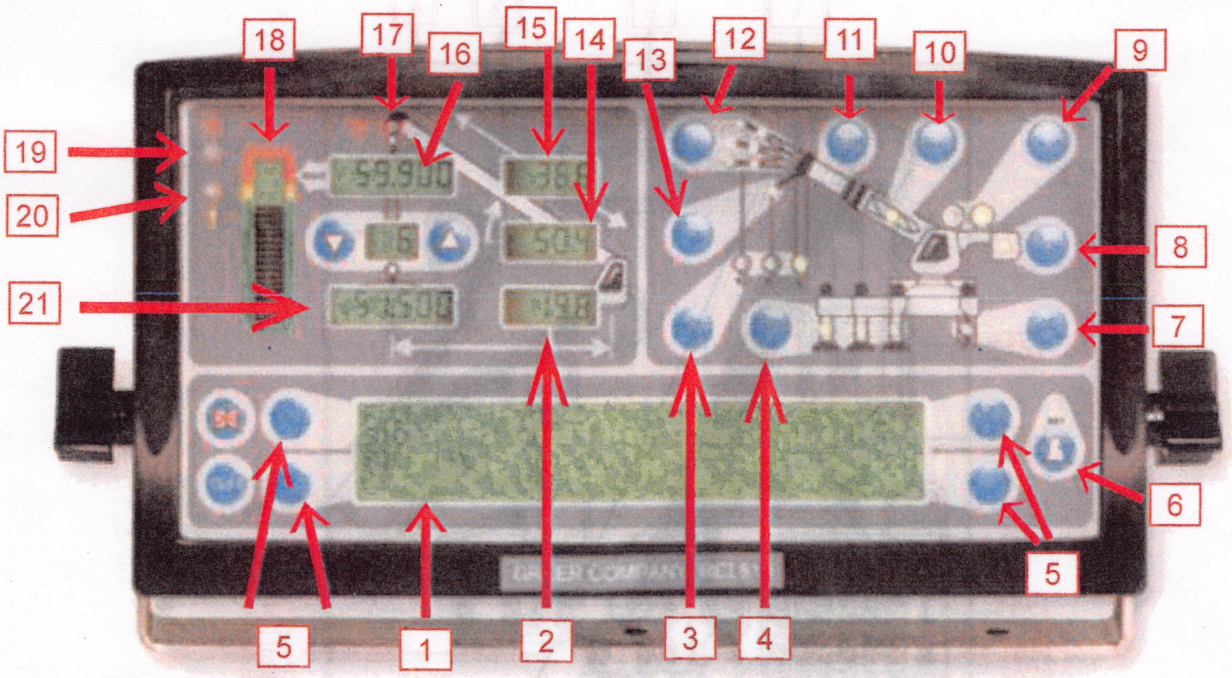
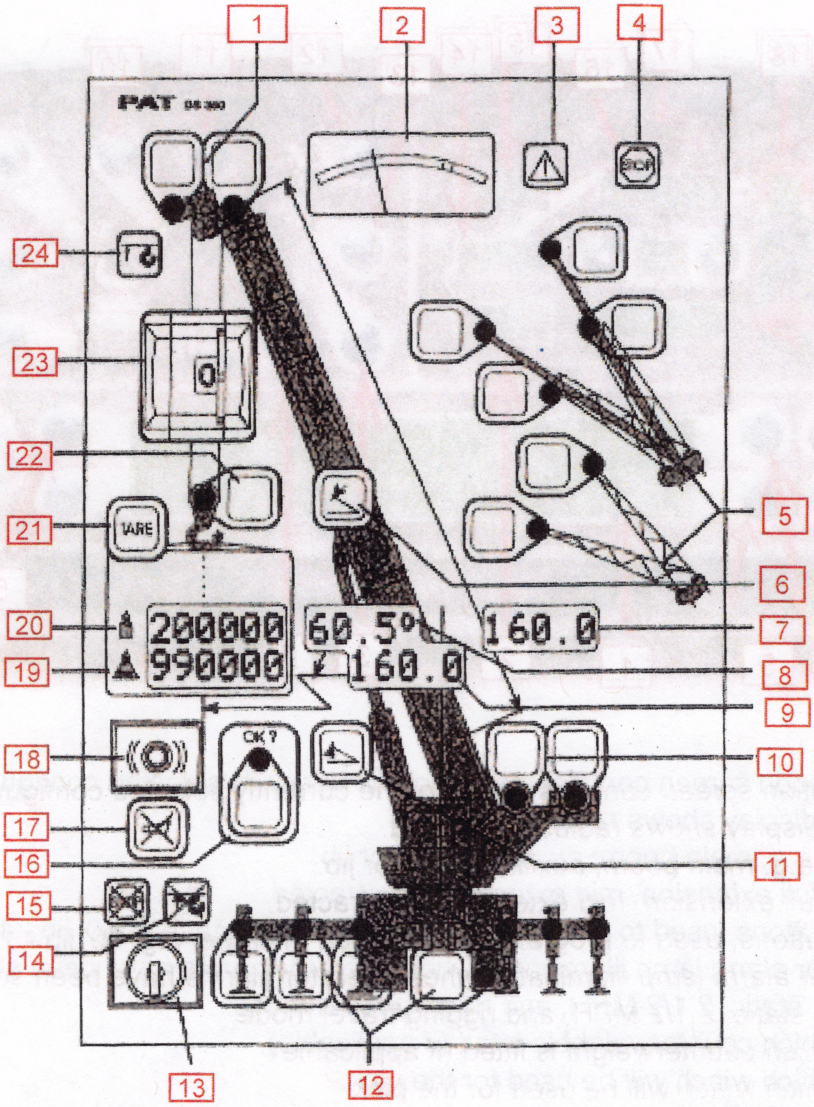
(o)(1) & (2)

Load Moment Indicator Display





1. The information screen contains details of the currently selected configuration.
2. The radius display shows radius of the load.
3. Point of lift, e.g. main boom, auxiliary head or jib.
4. Outriggers full extension, mid extension or retracted.
5. Selection buttons, used to program configuration of crane, e.g. 60' jib - 17° offset.
6. The operator alarm lamp illuminates when operator alarms have been set.
7. Tires creep, static, 2 1/2 MPH, and rigging/travel mode.
8. Indicates which counterweight is fitted (if applicable).
9. Indicates which winch will be used for the pick.
10. Jib stowed on boom.
11. Manual section or active tip extended (if applicable).
12. Indicates jib configuration in use.
13. Auxiliary head ON or OFF the crane.
14. The angle display indicates, in degrees, the angle of the main boom relative to horizontal.
15. The length display shows the length of the main boom.
16. The rated capacity display shows the rated capacity of the crane in current configuration.
17. The anti two-block lamp illuminates when the A2B limit switch detects approach to a Two-Block condition.
18. The bar graph indicates the actual load as a percentage of rated capacity.
19. The overload indicator (red) illuminates at a preset value of 100% of rated capacity.
20. The pre-alarm (amber) indicator illuminates at a preset value of 90% of rated capacity.
21. Actual load weight.



1. Boom Nose Selection Buttons and Control Lights
2. Load Moment Indicator
3. Load Moment Pre-warning Light
4. Load Moment Limit Light
5. Boom Extension Configuration Buttons and Control Lights
6. Boom and Control Light “Upper Boom Angle Limit“
7. Boom Length Display
8. Boom Angle Display
9. Radius Display
10. Hoist Line Selection Buttons and Controls Lights
11. Button and Control Light “Lower Boom Angle Limit“
12. Outrigger Configuration Buttons and Control Lights
13. By-Pass Key Switch
14. Override Key Warning Light
15. Control Light “Anti-Two-Block Override“
16. Button “Confirmation of Programming Procedure“
17. Button “Alarm Stop“
18. Audible Alarm
19. Display “Maximum Load“
20. Display “Actual Load“
21. Button and Control Light “Tare“
22. Button and Control Light “Reeving Selection“
23. Reeving Switch
24. Anti-Two-Block Alarm

Crane operations must not begin unless the operational aids are in proper working order, except where an operational aid is being repaired and the employer uses the specified "Temporary Alternative Measures" (TAM).

OSHA 1926.1416 (b)

If a listed Operational Aid stops working properly, the operator must safely stop work operations until the temporary alternative measures are implemented or the device is again working properly.

OSHA 1926.1416 (c)

Category 1 Operational Aids and Alternative measures:

- Category 1 operational aids not working must be repaired no later than 7 calendar days after deficiency occurs.
- If employer documents that the part has been ordered within 7 calendar days, the repair must be completed within 7 calendar days of receipt of the parts.

What are the three devices that fall into the Category 1 criteria?

» Boom hoist limiting device.

» Luffing jib limiting device.

» Anti two-blocking device.

These three devices have distinct "Temporary Alternative Measures"

What temporary alternative measures must be implemented if boom hoist limiting device stops working?

» Use a boom angle indicator.

» Clearly mark the boom hoist cable at a point to give the operator time to stop the hoisting function.

» Clearly mark the boom hoist cable at a point where the spotter will see and be able to warn the operator to stop hoisting.

A boom hoist limiting device is required for cranes manufactured after 12/16/1969.

OSHA
1926.1416 (d)(1)(i)

Boom Hoist limiting device temporary alternative measures are:

- Use a boom angle indicator.
- Clearly mark the boom hoist cable at a point to give operator notification to keep the boom within the minimum allowable radius.
- Clearly mark the boom hoist cable so that it can easily be seen by a spotter to signal the operator.

Luffing jib limiting device.

- Equipment with a luffing jib must have a luffing jib limiting device.
- It is very similar to a boom hoist limiting device except it limits the luffing jib.
- It also has the same temporary alternative measures as the boom hoist limiting device.

Anti Two-blocking Device

OSHA requires anti two-blocking devices with some conditions.

- On telescopic boom cranes (manufactured after 2/28/92). 1926.1416(d)(3)(i)
- On lattice boom cranes (after 2/28/92), but can also use device to warn operator in time to prevent two-blocking. 1926.1416(d)(3)(ii)(A)
- Cranes or derricks hoisting employees in a personnel cage. 1926.1501(g)(3)(ii)(C)

ANSI B30.5 states that anti two-blocking devices should be provided to prevent damage to the hoist rope or other machine parts when extending a telescopic boom. OSHA requires an anti two-blocking safety device be installed on cranes and derricks whenever used to hoist employees. OSHA 1926.1416(d)(3) describes the types of anti two-blocking device requirements for different types of cranes.

Telescopic Boom Cranes

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1926.1416 (d)(3)(i)

Telescopic boom cranes manufactured after February 28, 1992, must be equipped with a device which automatically prevents damage from contact between the load block, overhaul ball, or similar component, and the boom tip (or fixed upper block or similar component). The device(s) must prevent such damage at all points where two-blocking could occur.

Temporary alternative measures for anti two-block malfunction is: Clearly mark the cable (so that it can easily be seen by the operator) at a point that will give the operator sufficient time to stop the hoist to prevent two-blocking, and use a spotter when extending the boom.

Lattice Boom Cranes

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(d)(3)(ii)(A)

Lattice boom cranes manufactured after February 28, 1992, must be equipped with a device that either automatically prevents damage and load failure from contact between the load block, overhaul ball, or similar component, and the boom tip, or warns the operator in time for the operator to prevent two-blocking.

The device must prevent such damage/failure or provide adequate warning for all points where two-blocking could occur.

Two-blocking occurs when the hook block is pulled up into the boom tip sheaves.

Two-blocking mostly happens on hydraulic machines when the boom is extended and the line is not let out enough to accommodate the extra boom length. Some cranes may experience two-blocking when the boom is lowered and the load is positioned too close to the boom tip. Two-blocking can cause serious equipment damage such as severe damage to wire rope, hoist motors, sheaves, boom, etc. There are many cases of personal injury and death as a result of two-blocking incidents. Solenoid system is used to lock out power system to hoisting components.

Category 2 "Operational Aids and Alternative Measures"

- Operational aids listed in this paragraph that are not working properly must be repaired no later than 30 calendar days after the deficiency occurs.
- Exception! If the employer documents that it has ordered the necessary parts within 7 calendar days of the occurrence of the deficiency, and the part is not received in time to complete the repair in 30 calendar days, the repair must be completed within 7 calendar days of receipt of the parts.

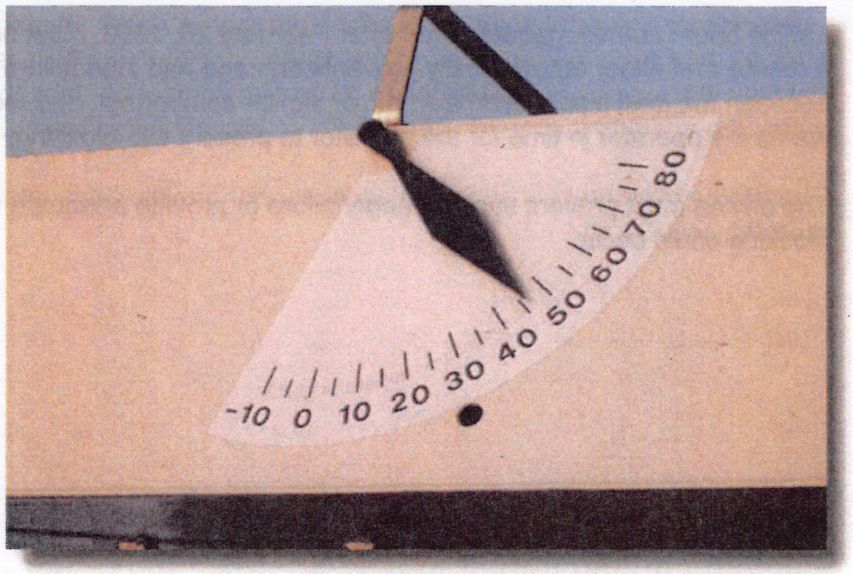
Boom Angle Indicator

This is a device that measures the angle between the horizontal and the longitudinal center line of the boom.

The boom longitudinal center line is a straight line between the boom foot pin (heel pin) center line and the boom point sheave pin center line.

According to OSHA (1926.1416 (e)(1)), "The equipment must have a boom angle indicator or radius indicator, readable from the operator's station.

The "Temporary Alternative Measure" for a boom angle indicator is that the boom angle must be determined by measuring the boom angle with a measuring device.



Radius Indicator

This is a device that measures the radius, which is:

> **"The horizontal distance from the center of rotation of the crane to the center of gravity of the load suspended."**

According to OSHA (1926.1416 (e)(1)), "The equipment must have a boom angle indicator or radius indicator, readable from the operator's station.

The "Temporary Alternative Measures" for the radius indicator is to measure the actual radius with a measuring device.

Jib Angle Indicator

This device is only required if the equipment has a luffing jib.

The "Temporary Alternative Measures" for the jib angle indicator is that the radius or jib angle must be determined by ascertaining the main boom angle and then measuring the radius or jib angle with a measuring device.

Boom Length Indicators

Boom length indicators must be equipped on all cranes with telescoping booms. Except when the rated capacity is independent of the boom length.

The operator must be aware of boom length and its effect on load radius and the stability of the crane.

Operators should always have a clear indication of the boom's length or accurate determination of the load radius.

Boom length may only be available as markings on the boom extension sections.

The "Temporary Alternative Measures" are:

- **Mark the boom with measured marks to calculate boom length.**
- **Calculate boom length from boom angle and radius measurements.**
- **Measure the boom with a measuring device.**

Hoist Drum Rotation Indicator

Drum rotation indicators MUST be provided and easy to sense.

The hoist drum rotation indicator is required if the equipment has a hoist drum not visible from the operator's station.

The drum rotation indicator may run off of a speedometer-type cable to inform the operator that the drum is actually rotating.

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1926.1416(e)(5)(ii)

The "Temporary Alternative Measures" for this indicator is to:

- **Mark the drum to indicate the rotation of the drum**
- **In addition, install mirrors or remote video cameras and displays if necessary for the operator to see the mark.**

Outrigger/Stabilizer Position Sensor/Monitor

Only applies if the equipment has outriggers or stabilizers.

The "Temporary Alternative Measures" are:

- **The operator must verify that the position of the outriggers or stabilizers is correct before beginning operations requiring outrigger or stabilizer deployment.**

Outrigger beams must be marked or painted in a manner to indicate the fully extended position. Outriggers that can be used in a semi-extended position must have intermediate stop positions clearly marked when extending. Each outrigger must be visible from its actuating location unless the operator is assisted by a signal person.

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1926.1404(q)

ANSI B30.5 Section 5-1.9.3 states that the outriggers must be securely mounted, clearly visible from its actuating location, floats securely fastened, and power actuated jacks, where used, must be provided with means to prevent loss of support under load.

ANSI B30.5 Section 5-3.2.3.i states that outriggers must be used when the load to be handled at that particular radius exceeds the rated load without outriggers as given by the crane manufacturer.

Load Indicators

OSHA 1926.1416(e)(4)

Crane manufacturers employ one of two load indicating device methods of determining the load supported by the crane.

Load indicating devices are not standard equipment, they are an option that should always be chosen and/or requested, especially on equipment that is rented or leased. These devices need periodic recalibration to ensure accuracy. The scale method uses equipment that will be more accurate than operator calculation or estimation. Operators must have accurate information regarding the weight of the load and the operating radius to precisely determine the weight of the load.

Scale method

Total effective hook load calculation

The scale method is a direct measurement of load weight by equipment such as tension meters, strain gauges, or scales.

Equipment manufactured after 3/29/03, with a rated capacity over 3 tons must have at least one of the following:

- **Load weighing device.**
- **Load moment or rated capacity indicator.**
- **Load moment or rated capacity limiter.**

Boom Hoist & Luffing Jib Hoist Limiting Device

A boom hoist limiting device is required for cranes manufactured after 12/16/1969.

The "Temporary Alternative Measures" are:

- **Use a boom angle indicator**
- **Clearly mark the boom hoist wire rope so as to be easily seen by the operator or by a spotter.**

What temporary alternative measures must be implemented if boom hoist limiting device stops working?

OSHA 1926.1416 (d)(1)(i)(B) 1926.1416 (d)(1)(i)(C)

» Clearly mark the boom hoist wire rope so that it can be easily seen by the operator or a spotter, or install mirrors or remote video cameras and displays if necessary.

Safety Devices

1. Crane Level Indicator

The equipment MUST have a crane level indicator that is either built into the equipment or is available on the equipment.

If a built-in crane level indicator or a removable crane level indicator is not working properly they must be removed from service.

This requirement does not apply to portal cranes, derricks, floating cranes/ derricks and land cranes/derricks on barges, pontoons, vessels or other means of flotations.

2. Boom Stops

All lattice boom cranes must be equipped with boom stops.

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1926.1415(a)(2)

They may prevent the boom from being pulled backwards over the cab and limit the backward movement of the boom past a predetermined point. These do not apply to derricks and/or hydraulic booms. These are devices whose sole purpose is to limit the maximum angle to where the boom should be derricked (raised). Once the boom moves past a certain high angle, the stability of the crane is in question and it can tip over. Boom stops prevent accidents that can cause severe equipment damage and personal injuries.

3. Jib Stop

These do not apply to derricks.

These are somewhat similar to a boom stop but are for a fixed or luffing jib.

4. Equipment with foot pedal brakes must have locks.

A brake or other equivalent device adequate to bring the mobile crane to a stop from any travel for which such crane is designed, together with a means of locking such mobile crane so as to hold it stationary.

5. Hydraulic outrigger jacks and hydraulic stabilizer jacks must have an integral holding device/check valve.

6. Equipment on rails must have rail clamps and rail clamps and rails stops.

Does not apply to portal cranes.

7. Horn

The equipment must have a horn that is either built into the equipment, or is on the equipment and immediately available to the operator.

Proper operation is required for all 7 of these safety devices.

Operations must not begin unless all of these safety devices are in proper working order.

If a device stops working properly during operations, the operator must safety stop operations.

If any of the devices listed in this section are not in proper working order, the equipment must be taken out of service and operations must not resume until the device is again working properly.

Alternative measures are not permitted to be used.